

*WHAT IS CLAIMED IS:*

1. Purifying apparatus for removing charged contaminants from a water stream, comprising:

- 5 (a) a first cation exchange membrane with exchangeable cations and a first anion exchange membrane with exchangeable anions both having inner and outer walls, the inner walls of said first cation and anion membranes defining a first purifying flow channel therebetween, said first cation and anion exchange membranes preventing bulk liquid flow but passing ions of the same charge as the corresponding exchangeable ions,
- 10 (b) a first cation chamber defining a first cation flow channel on the outer wall side of said first cation exchange membrane,
- (c) a first anion chamber defining a first anion flow channel on the outer wall side of said first anion exchange membrane,
- (d) a cathode and an anode in electrical communication with said first cation flow channel and said first anion flow channel, respectively,
- 15 (e) flow-through first ion exchange medium disposed in said first cation flow channel,
- (f) flow-through second ion exchange medium disposed in said first anion flow channel, and
- 20 (g) a zone within and coextensive with the length of said first purifying flow channel free of flow-through ion exchange medium or having flow-through ion exchange medium with an ion exchange capacity no greater than 25% of said first and second ion exchange media.

2. The purifying apparatus of Claim 1 in which said first ion exchange medium is predominantly in the cation exchange form.

3. The purifying apparatus of Claim 1 in which said first ion exchange medium is predominantly in the anion exchange form.
4. The purifying apparatus of Claim 1 in which said second ion exchange medium is predominantly in the anion exchange form.
- 5 5. The purifying apparatus of Claim 1 in which said second ion exchange media is predominantly in the cation exchange form.
6. The purifying apparatus of Claim 1 in which said zone is substantially free of flow-through ion exchange medium
7. The purifying apparatus of Claim 1 in which said first purifying channel is substantially free of flow-through ion exchange medium.
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8. The purifying apparatus of Claim 1 in which said first ion exchange medium comprises an ion exchange screen.
9. The purifying apparatus of Claim 1 in which said second ion exchange medium comprises an ion exchange screen.
- 15 10. The purifying apparatus of Claim 1 in which said first and second ion exchange media comprise media having a mixture of exchangeable cations and anions.
11. The purifying apparatus of Claim 1 including second cation and anion exchange membranes defining a second purifying flow channel therebetween, second cation or anion flow chambers defining second cation or anion flow channels, respectively, flow-through second ion exchange resin disposed in said second cation or anion flow channels,
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a zone within and coextensive with the length of said second purifying flow channel being free of flow-through ion exchange medium having an ion exchange capacity greater than 25% of said first and second ion exchange media.

12. A method for purifying a water stream by removing charged contaminants therefrom, said method comprising the steps of:

(a) flowing said water stream through a purifying flow channel defined by a cation exchange membrane with exchangeable cations disposed along one side of said purifying flow channel and an anion exchange membrane with exchangeable anions disposed along the other side of said purifying flow channel, said anion and cation exchange membranes preventing bulk liquid flow but passing ions of the same charge as the corresponding exchangeable ions, a zone within and coextensive with the length of said purifying flow channel free of flow-through ion exchange medium or having flow-through ion exchange medium with an ion exchange capacity no greater than 25% of said first and second ion exchange media,

(b) flowing an aqueous stream through first ion exchange medium in a cation flow channel on the opposite side of said cation exchange membrane from said purifying flow channel,

(c) flowing an aqueous stream through second ion exchange medium in an anion flow channel on the opposite side of said anion exchange membrane from said purifying flow channel, and

(d) during steps (a), (b) and (c), applying an electrical potential between a cathode in electrical communication with said cation flow channel and an anode in electrical communication with said anion flow channel.

13. The method of Claim 12 in which said first ion exchange medium is predominantly in the cation exchange form.

14. The method of Claim 12 in which said first ion exchange medium is predominantly in the anion exchange form.

15. The method of Claim 12 in which said second ion exchange medium is predominantly in the anion exchange form.

5 16. The method of Claim 12 in which said second ion exchange media is predominantly in the cation exchange form.

17. The method of Claim 12 in which said purifying channel is substantially free of flow-through ion exchange medium.

10 18. The method of Claim 12 in which said first ion exchange medium comprises an ion exchange screen.

19. The method of Claim 12 in which said second ion exchange medium comprises an ion exchange screen.

20. The method of Claim 12 in which said first and second ion exchange media comprise media having a mixture of exchangeable cations and anions.

15 21. The method of Claim 12 in which steps (a) - (d) are performed in at least second parallel purifying, cation or anion flow channels.

22. The method of Claim 12 in which said zone is substantially free of flow-through ion exchange medium.

23. Apparatus for purifying an aqueous liquid stream for flowing the same to an analytical system, said apparatus comprising

- (a) a flow-through water purifier having an inlet and an outlet,
- (b) a pressurized source of impure water communicating with said purifier inlet,
- (c) an analytical pump,
- (d) a first conduit disposed between said purifier outlet and said pump,
- (e) a liquid stream splitter having a diversion outlet, disposed between said impure water source and said purifier inlet, or between said purifier outlet and said analytical pump, said splitter splitting the liquid stream flowing to the splitter inlet into a first and second stream, and
- (f) a second conduit providing fluid communication between said diversion outlet and said purifier.

24. The apparatus of Claim 23 in which said splitter is disposed between said impure water source and said purifier.

25. The apparatus of Claim 24 in which said purifier comprises

- (g) a first cation exchange membrane with exchangeable cations and a first anion exchange membrane with exchangeable anions, both said membranes having inner and outer walls, the inner walls of said first cation and anion membranes defining a first purifying flow channel therebetween, said first cation and anion exchange membranes preventing bulk liquid flow but passing ions of the same charge as the corresponding exchangeable ions.

- (h) a first cation chamber defining a first cation flow channel on the outer wall side of said first cation exchange membrane,
- (i) a first anion chamber defining a first anion flow channel on the outer wall side of said first anion exchange membrane,

(j) a cathode and an anode in electrical communication with said first cation flow channel and said first anion flow channel, respectively,

(k) flow-through first ion exchange medium disposed in said first cation flow channel,

5 (l) flow-through second ion exchange medium disposed in said first anion flow channel, and

(m) a zone within and coextensive with the length of said first purifying flow channel free of flow-through ion exchange medium or having flow-through ion exchange medium with an ion exchange capacity no greater than 25% of said first and second ion exchange media, and said second conduit providing fluid communication between said  
10 diversion outlet and said cation and anion chambers.

26. The apparatus of Claim 23 further comprising

(g) an analytical system reservoir disposed along said first conduit between said purifier outlet and said analytical pump.

15 27. The apparatus of Claim 23 in which said splitter is disposed between said purifier outlet and said analytical pump.

28. The apparatus of Claim 27 in which said second conduit provides fluid communication between said diversion outlet and said purifier inlet.

29. The apparatus of Claim 27 in which said purifier comprises  
20 (g) a first cation exchange membrane with exchangeable cations and a first anion exchange membrane with exchangeable anions, both said membranes having inner and outer walls, the inner walls of said first cation and anion membranes defining a first purifying flow channel therebetween, said first cation and anion exchange membranes

preventing bulk liquid flow but passing ions of the same charge as the corresponding exchangeable ions.

(h) a first cation chamber defining a first cation flow channel on the outer wall side of said first cation exchange membrane,

5 (i) a first anion chamber defining a first anion flow channel on the outer wall side of said first anion exchange membrane,

(j) a cathode and an anode in electrical communication with said first cation flow channel and said first anion flow channel, respectively,

10 (k) flow-through first ion exchange medium disposed in said first cation flow channel,

(l) flow-through second ion exchange medium disposed in said first anion flow channel, and

15 (m) a zone within and coextensive with the length of said first purifying flow channel free of flow-through ion exchange medium or having flow-through ion exchange medium with an ion exchange capacity no greater than 25% of said first and second ion exchange media, said second conduit providing fluid communication between said diversion outlet and said cation and anion chambers.

30. The apparatus of Claim 23 in which said analytical system is a chromatography system and said analytical pump is a chromatography pump.

20 31. A method for purifying an impure aqueous liquid stream and for flowing the same to an analytical system, comprising:

(a) purifying the impure aqueous stream by flowing the same from a pressurized source through a purifier having an inlet and an outlet,

25 (b) flowing said purified aqueous stream from said purifier outlet through an analytical pump,

(c) splitting said impure aqueous stream between said pressurized source and said purifier so that only part of said impure aqueous stream is purified in said purifier, or splitting said purified aqueous stream from said purifier outlet so that only part of said purified liquid stream flows through said analytical pump.

5 32. The method of Claim 31 in which said purified aqueous stream flows through an analytical system reservoir prior to flowing through said analytical pump.

33. The method of Claim 31 in which the purifying step (a) is performed by

10 (d) flowing said impure aqueous stream through a purifying flow channel in said purifier defined by a cation exchange membrane with exchangeable cations disposed along one side of said purifying flow channel and an anion exchange membrane with exchangeable anions disposed along the other side of said purifying flow channel, said anion and cation exchange membranes preventing bulk liquid flow but passing ions of the same charge as the corresponding exchangeable ions, a zone within and coextensive with the length of said purifying flow channel free of flow-through ion exchange medium or  
15 having flow-through ion exchange medium with an ion exchange capacity no greater than 25% of said first and second ion exchange media,

(e) flowing an aqueous stream through first ion exchange medium in a cation flow channel on the opposite side of said cation exchange membrane from said purifying flow channel,

20 (f) flowing an aqueous stream through second ion exchange medium in an anion flow channel on the opposite side of said anion exchange membrane from said purifying flow channel, and

(g) during steps (d), (e) and (f), applying an electrical potential between a cathode in electrical communication with said cation flow channel and an anode in  
25 electrical communication with said anion flow channel.



34. The method of Claim 33 in which said impure liquid stream is split prior to flow into said purifier inlet and part of said split stream flows through said cation and anion exchange channels.

5 35. The method of Claim 33 in which said purified liquid stream is split after flow through said purifier and prior to flow through said pump and part of said split stream flows through said cation and anion exchange channels.

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